

CLAIMS:

1. An apparatus for photo-electric measurement comprising:
 - a) a single or a plurality of photo-electric conversion devices, preferably array sensor(s) such as CCD, CMOS, CID and the like;
 - b) an optical system which is modularly expandable in one axis or a plurality of axes in order to acquire electromagnetic radiation from a line or area of any desired size on an object; with any desired resolution, wherein the said optical system preferably separates the said electromagnetic radiation modularly into a plurality of smaller segments, and projects electromagnetic radiation corresponding to the said smaller segments onto said single or a plurality of individual photo-electric conversion devices; and
 - c) sensor electronics related to said photo-electric conversion device(s) which enable the operating mode and functionality of said photo-electric conversion device(s) to be defined and changed in real-time, whereby functions such as the readout sequence of pixels and unlimited flexibility of pixel binning in two dimensions are fully programmable, and said photo-electric conversion device(s) may operate and/or be controlled independently and/or simultaneously.
2. The apparatus according to Claim 1, wherein said segments of electromagnetic radiation originate from a plurality of overlapping regions on the line or area to be measured.
3. The apparatus according to Claim 1, wherein the said segments of electromagnetic radiation originate from one or a plurality of regions on the line or area to be measured, whereby the regions are adjacent to each other, or there may be space corresponding to regions of no measurement interest between the said regions, wherein the apparatus preferably provides its functionality only for regions to be measured.

4. The apparatus according to any one of Claims 1 to 3, wherein said optical system provides a magnification which may be more than, equal to, or less than one.
5. The apparatus according to any one of Claims 1 to 4, wherein the said photo-electric conversion device(s) comprise a plurality of readily available, off-the-shelf array sensors positioned adjacent to each other, wherein said array sensors preferably comprise semiconductor die(s) which are housed in an integrated circuit package.
6. The apparatus according to any one of Claims 1 to 5, wherein the said photo-electric conversion device(s) comprise a plurality of buttable array sensors positioned adjacent to each other, being stackable side-to-side such that there is minimum dead space between the active areas.
7. The apparatus according to any one of Claims 1 to 6, wherein said photo-electric conversion device(s) include any one or any subset of the following features:
 - a) a means of clearing charge from the photo-electric conversion device(s) very fast, such as the draining of all charge in the photo-electric conversion device and/or in serial register(s) of said photo-electric conversion device via a single pulse, or the like,
 - b) summing well(s) at each of the output(s) of the photo-electric conversion devices,
 - c) metal strapped gates and connections to increase clocking speeds,
 - d) thinned, back-illuminated CCD technology,
 - e) low dark current "Multi-Pinned Phase (MPP)" operation mode,
 - f) frame transfer architecture,
 - g) interline transfer architecture,
 - h) full-frame transfer architecture,
 - i) charge amplification on the photo-electric conversion device, such as by avalanche or impact ionisation effects or the like,
 - j) fiber optic bundle(s) directly bonded to the photo-electric conversion device,

- k) a single or a plurality of outputs,
 - l) a single or a plurality of serial (readout) register(s),
 - m) segmentation of the photo-electric conversion device(s), whereby all segments may be read and/or controlled individually and/or simultaneously.
 - n) integrated microlenses,
 - o) anti-blooming in the active area, storage area and/or serial register(s).
 - p) Charge multiplication integrated on the image sensor.
8. The apparatus according to any one of Claims 1 to 7, wherein said optical system comprises the integration of one or any combination of micro-optical components such as refractive, diffractive, reflective, absorptive elements, fiber optical, and/or spatially filtering elements, and/or one or more arrays thereof.
9. The apparatus according to any one of Claims 1 to 8, further comprising a cooling means, preferably using thermo-electric (Peltier) device(s) for cooling and/or temperature regulating said photo-electric conversion device(s).
10. The apparatus according to Claim 9, further comprising an enclosure which houses said cooled photo-electric conversion device(s) and related cooling means for preventing condensation on surfaces which are in the optical path, wherein said enclosure is preferably hermetically sealed, and more preferably under vacuum or filled with an inert gas such as Argon or the like.
11. The apparatus according to any one of Claims 1 to 10, wherein said optical system forms an integral part of an enclosure which houses said photo-electric device(s).
12. The apparatus according to any one of Claims 1 to 11, wherein said optical system is factory pre-aligned spatially and spectrally with respect to said photo-electric conversion device(s) such that the focal plane of the object to be measured and the positioning of the electromagnetic radiation incident on the

device(s) is within specified tolerances.

13. The apparatus according to any one of Claims 1 to 12, further comprising excitation (illumination) electromagnetic radiation wherein the focus thereof is factory pre-aligned spatially with respect to the said optical system and photo-electric conversion device(s) such that the measurement performance is optimised within specified tolerances, wherein the said measurement performance preferably comprises one or a plurality of the following: focal, spectral and spatial positioning and resolution; sensitivity; limit of detection, acquisition speed.
14. The apparatus according to any one of Claims 1 to 13, wherein said optical system includes a means for coupling into the optical system, and focusing said excitation (illumination) electromagnetic radiation at the line or area to be measured.
15. The apparatus according to any one of Claims 13 or 14, wherein the apparatus includes a means for spatially varying the said excitation (illumination) at the line or area to be measured, wherein said means is preferably real-time programmable, preferably integrated with the optical system, and most preferably uses LCD-, acousto-optic-, micro-mirror-based spatial light modulator(s) or the like.
16. The apparatus according to any one of Claims 1 to 15, wherein all components of the apparatus are tightly integrated into a compact, miniaturized measurement unit, preferably with all components of said micro-optic system permanently fixed relative to each other and to said photo-electric conversion device(s), with no mechanical adjustments.
17. The apparatus according to any one of Claims 1 to 16, wherein the said optical system includes a means for spreading electromagnetic radiation according to wavelength, and projects the resulting spectra onto said photo-electric

conversion device(s).

18. The apparatus according to any one of Claims 1 to 17, wherein the functionality of said optical system and said photo-electric conversion device(s) is spatially variable, such that for example measurements of various types can be simultaneously performed.
19. The apparatus according to any one of Claims 1 to 18, wherein said optical system is a confocal system, and comprises at least one spatial filter whereby electromagnetic radiation from a plurality of points on the line or area to be measured is spatially filtered at particular refocusing points and/or planes, and said spatial filter is preferably implemented by a pinhole or slit which may be implemented using absorptive, diffractive, refractive element(s), and/or may be defined by one or a plurality of programmable sub-area(s) of pixels of said photo-electric conversion device(s).
20. The apparatus according to any one of Claims 17 to 19, wherein the apparatus is modularly expanded in a first direction to measure a particular length of a line on an area presented by a target object, and comprises means for moving, the apparatus preferably in a stepped and/or scanned manner in a second direction in order to measure said area.
21. The apparatus according to Claim 20, wherein said apparatus produces image(s) of an area or a plurality of sub-areas thereof, whereby said photo-electric conversion device(s) is/are preferably operated in "Time Delayed Integration" mode, line scanning mode, or imaging mode.
22. The apparatus according to Claim 21, preferably in combination with Claim 17 wherein the electromagnetic radiation from the area to be measured, or sub-areas thereof, is spread spectrally onto said photo-electric conversion device(s) capabilities and wherein the spectral axis is perpendicular to the axis of movement of the apparatus.

23. The apparatus according to any one of Claims 17 to 22, wherein a plurality of measurement lines in said first direction are simultaneously measured, said measurement lines being positioned sequentially in the direction of movement of the apparatus.
24. The apparatus according to any one of Claims 17 to 23, wherein said means of spreading electromagnetic radiation according to wavelength comprises a binary grating, particularly preferred is a single level or single mask binary grating, wherein the odd or minus one and even or plus one first order spectra are both acquired simultaneously by the apparatus.
25. The apparatus according to Claim 24, further comprising combining means for combining said odd and even first order spectra on the photo-electric conversion device(s), preferably during the readout process via pixel binning.
26. The apparatus according to Claim 24, wherein said sensor electronics combines said odd and even first order spectra in analog manner.
27. The apparatus according to Claim 24, wherein said sensor electronics combines said odd and even first order spectra digitally, preferably in a real-time, in-line fashion.
28. The apparatus according to Claim 24, wherein said controller combines said odd and even first order spectra digitally, preferably in a real-time, in-line fashion.
29. The apparatus according to any one of Claims 1 to 28, wherein said excitation (illumination) source and related electronics is an integral part of the apparatus, whereby said optical system delivers electromagnetic radiation from said optical source to the object to be measured.
30. The apparatus according to any one of Claims 1 to 29 for "excitation gated" and/or "emission lifetime" -aided measurements, comprising:

- a) means for pulsing the excitation (illumination) source, whereby a measurement may include a single or a plurality of said pulses,
 - b) means for sensing the electromagnetic radiation pulse at the wavelength band corresponding to the excitation (illumination) source and means for detecting the electromagnetic radiation pulse at the plane of the said photo-electric conversion device(s),
 - c) means for collecting desired electromagnetic radiation by the active area of said photo-electric conversion device(s) only during a programmably defined time, relative to the excitation pulse, and
 - d) means for integrating/summing the emission signal collected after each excitation pulse in shaded "storage" regions on the said photo-electric conversion device(s), which are read after a single or a plurality of excitation pulses, wherein said collecting means and said integrating/summing means are preferably implemented on an individual pixel basis.
31. The apparatus according to Claim 30, wherein the sensing means, detecting means, collecting means and integrating/summing means, as well as all related circuitry are integrated onto the said photo-electric conversion device(s).
32. The apparatus according to Claim 30, wherein the sensing means, collecting means and integrating/summing means are integrated on separate photo-electric conversion device(s), and the pulsing means and the detecting means are located in close proximity to the photo-electric conversion device(s).
33. The apparatus according to any one of Claims 1 to 32, further comprising a means of mechanically moving and/or positioning the apparatus in up to three dimensions with respect to the object to be measured, wherein the said means of positioning is further controllable by said controller in real time during measurement.
34. The apparatus according to any one of Claims 1 to 33, further comprising a controller, preferably the intelligent detector according to Patent Application

No. PCT/EP01/11027 filed on September 24, 2001, titled "Image Sensor Device, Apparatus and Method for Optical Measurements", wherein said controller is preferably an integral part of the apparatus.

35. The apparatus according to Claim 34, further comprising means for separately transmitting the results of measurements from the said overlapping segments to the said controller, where they are combined into a single data stream.
36. The apparatus according to Claim 34, further comprising means for combining the results of measurements from the said overlapping segments into a single data stream by the said sensor electronics, and for transmitting the single data stream to the said controller.
37. The apparatus according to Claim 34, wherein a processing means in said controller compensates for the overlapping of segments, providing a result representing the measurement of the entire line or area without gaps.
38. The apparatus according to Claim 37, wherein said processing means comprises programmable logic and a related software program.
39. The apparatus according to Claim 37, wherein said processing means comprises a micro-controller and a related software program.
40. The apparatus according to Claim 37, wherein said processing means comprises one or a plurality of Digital Signal Processor(s) (DSP) and related software program(s).
41. A method of optimising measurement of the said spectra in real-time using the apparatus according to any one of Claims 17 to 40, wherein the relatively higher electromagnetic radiation from the zeroth order and/or from excitation (illumination) source(s) are sensed by the said photo-electric conversion device(s) and information derived immediately used to adapt for the actual location of the spectra. Preferably the said zeroth order and/or excitation, as

well as a plurality of spectral bandwidths are sensed via programmable two-dimensional pixel binning.

42. A method of optimising performance in real-time during measurement using the apparatus according to any one of Claims 34 to 40, wherein the measurements obtained from a single or a plurality of measurement lines is immediately evaluated by the said controller, and the result used to optimize the measurement performed by a single or a plurality of following measurement line(s).
43. A method of optimising performance in real-time during measurement from plane areas which are tilted (non-parallel) with respect to the apparatus, using the apparatus according to any one of Claims 34 to 40, wherein the position of the apparatus is adapted during the measurement such that the focus along the entire measurement line is optimal.
44. A method for optimization of sensitivity of the apparatus according to any one of Claims 34 to 40 in real time during the measurement process, whereby the location and size of the sub-areas of pixels used to measure particular wavelength bands of the spectra projected onto said photo-electric conversion device(s) are optimised by the said controller based on information previously acquired by the apparatus, wherein in particular, spectral resolution versus sensitivity tradeoff is optimised.
45. A method for optimization of the performance of the apparatus according to any one of Claims 34 to 40 in real time during the measurement process, whereby the spectral axis of measurement on the said photo-electric conversion device(s) is calibrated in real time using information derived from the current or previously measured spectra, wherein preferred features in the spectra which are used for the said optimisation include the excitation (illumination) signal, reference spectral standards on the object to be measured, known RAMAN scatter profiles, and the like.

46. A method of optimising performance in real-time during measurement using the apparatus according to any one of Claims 34 to 40, wherein information is acquired by the apparatus from the object to be measured, and directly used to optimize the measurements, wherein said information may originate from a sample carrier, and/or from the samples themselves.
47. A method of optimising performance in real-time during measurement using the apparatus according to any one of Claims 34 to 40, wherein optical and measurement effects of mechanical tolerances, non-ideal mechanical motion such as jitter, vibration, hysteresis, and the like are reduced or eliminated, wherein spectral effects by real-time spectral calibration, using references on the object for optimization of measurements in real-time, are corrected.
48. A method of automating the processing and/or information management of the target object(s) and/or samples to be measured using the apparatus according to any one of Claims 34 to 40, wherein information acquired by the apparatus from said object or samples to be measured may serve as identification, may define or influence the processing, or the like, wherein said information may originate from a sample carrier, and/or from the samples themselves.
49. A method for information management of the target object(s) and/or samples to be measured using the apparatus according to any one of Claims 34 to 40, wherein the apparatus may store or write information on the said object or samples, such as date, time, measurement parameters, results, and the like.
50. The use of the apparatus according to any one of Claims 1 to 40 and/or the method(s) according to any one of Claims 41 to 49 for real-time measurement during or end-point measurement after processes, reactions and the like, such as those related to chemistry, bio-chemistry, biotechnology, molecular biology, and the like, wherein particular preferred processes measure include molecular hybridization processes, Surface Plasmon Resonance, binding between molecules, cells, and the like.

51. The use of the apparatus according to any one of Claims 1 to 40 and/or the method(s) according to any one of Claims 41 to 49 for the measurement of fluorescence, laser induced fluorescence, luminescence/chemi-luminescence, fluorescence and luminescence lifetime, reflectance and absorbance.
52. The use of the apparatus according to any one of Claims 1 to 40 and/or the method(s) according to any one of Claims 41 to 49 for measurements from microplates, microplates, micro-arrays, biological chips "biochips", samples spotted onto microscope slides, a plurality of micro-beads.
53. The use of the apparatus according to any one of Claims 1 to 40 and/or the method(s) according to any one of Claims 41 to 49 with detection methods involving Polymerase Chain Reaction (PCR), particularly used for genetic sequence detection.